REMARKS

The present invention relates to both a method and apparatus for measuring distance utilizing the time of flight (TOF) principle. Under the TOF principle, elapsed time between the transmission of an electromagnetic radiation and the receipt of its echo is directly proportional to the distance measured since the speed of light of electromagnetic radiation is a known and fixed constant, namely the speed of light.

Utilization of the TOF principle to measure distances has long been known in the art. One difficulty, however, with devices utilizing the TOF principle to measure distance is that electromagnetic noise may interfere with the received echo of the transmitted electromagnetic radiation pulse. This is particularly true as the distance increases which likewise results in reduced strength of the echo pulse. With previous devices, after a certain distance, the echo pulse is lost in the noise.

The present invention, however, overcomes this disadvantage of the previously known TOF distance measuring devices by providing both a method as well as an apparatus for identifying the actual reflected pulse from the target even where the reflected pulse lies below the noise level. In effect, Applicant's invention provides both a method as well as an apparatus for pulling the desired reflected pulse out of the noise.

Applicant achieves his invention by measuring the noise – which also contains the desired reflected pulse signal – only at specific points of time determined at which at least one threshold of the receiver which lies below the noise level is passed through and detecting changes in the noise caused by the signal pulses. Applicant achieves this by averaging a plurality of individual measurements of the noise at the specific points of time to thereby identify the reflected signal pulse. This is clear from Figs. 5a-5f in the patent drawing in which the

reflected signal pulse 15 is finally pulled out of the noise as shown in Fig. 5f. The distance calculation using the TOF principle is then performed only on the identified signal pulse formed by averaging the plurality of individual measurements at the specific points in time.

The independent claims, namely claims 33, 55, 63 and 64, have all been amended in order to clarify Applicant's invention. In particular, these claims have been amended to clarify that the averaging of the plurality of individual measurements at the specific points of time is performed to identify the reflected signal pulse. These amendments further clarify that the TOF calculation, i.e. the pulse propagation time, is only performed on the identified reflected signal pulse.

In view of the amendments to the claims, Applicant respectfully submits that the Patent Examiner's prior rejection of the claims can no longer stand. The Patent Examiner, however, has rejected previously submitted claims 33, 35-38, 43, 46-47, 55-56, 58-60 and 63-64 as unpatentably obvious over U.S. Patent Application Publication US 2004/0075823 to Lewis when combined with U.S. Patent Application Publication US 2002/0145725 to Ogawa. The Lewis reference admittedly discloses a method of distance measurement utilizing the TOF principle. Lewis achieves this by creating a digital curve of the received echo signal together with the accompanying noise at each of different comparison thresholds. Lewis then adds the different digital curves or histograms together for each sequential TOF electromagnetic pulse in order to obtain the final digital curve having the true signal clearly differentiated from the random background noise. This is perhaps best explained in paragraph [0087] of Lewis in which Lewis utilizes a control engine 20 which aggregates the histogram information at each threshold to create a composite waveform that serves as a digital replication of the waveform received by the laser diode 26.

Lewis is quite unlike Applicant's invention as it is now more clearly defined in the claims. In particular, the claims clearly define not only that the reflected pulse is below the noise level, but that the noise level, which also contains the desired reflection pulse, is measured only at specific points of time determined at which at least one threshold of the receiver line in the noise is passed through. Lewis simply does not teach this aspect of Applicant's invention.

Furthermore, in Applicant's invention, changes in the noise caused by the desired reflection pulse are identified by averaging a plurality of individual measurements of noise at the specific points of time and, thereafter, calculating the distance by utilizing that identified pulse. Lewis simply does not teach this aspect of Applicant's invention.

The Patent Examiner, apparently recognizing this, then relies upon the Ogawa patent publication. Specifically, the Patent Examiner has concluded that Ogawa teaches using only points in time when the noise is passed through the threshold and the Examiner specifically references Figure 8 and paragraph [0050] of Ogawa. Applicant, however, respectfully submits that the Patent Examiner has read more into the Ogawa publication than exists.

More specifically, paragraph [0050] of the Ogawa publication only describes the handling of a relatively low signal pulse, i.e. a signal pulse or echo pulse which lies slightly above the threshold Vth. The Ogawa reference is only able to distinguish between pulses in which the difference between the two pulses in time is below or above a certain predetermined value Tpth2; see FIG. 8B. This, however, is not Applicant's invention as it is clearly defined in the claims.

More specifically, there is absolutely no suggestion in the Ogawa patent of measuring the noise only at specific points in time at which at least one threshold of the receiver lying in the

noise is passed through. Indeed, there is absolutely no suggestion in Ogawa of actually being able to extract an echo pulse which lies in the noise.

The Patent Examiner has also rejected the independent claims in this case as unpatentable over U.S. Patent Application Publication No. US 2003/0035097 to Lai. In the Lai patent publication, Lai accumulates a plurality of individual TOF measurements that are sequentially obtained. These measurements of the real signal pulse at time T_d together with the noise are simply added together over a plurality of different measurements, for example eight different TOF measurements.

Due to the statistical nature of noise, i.e. that the noise is generally random, the noise distribution over the time domain is random for each of the several TOF measurements while the true return signal pulse at time T_d is not, but rather occurs at the same elapsed time for each of the numerous sequential measurements. Consequently, in order for the Lai application to identify the real echo radiation and to differentiate that radiation from the random noise, Lai effectively creates a digital curve of the received signal above a threshold 80 for the first TOF measurement. The same is performed for a second digital curve and so on for each of the sequential digital curves.

The Lai reference requires substantial computing power to not only create the digital curves, such as shown in FIG. 3 of Lai, for each TOF measurement, but also significant computing power to add the sequential TOF digital curves together. This is unlike Applicant's invention in which a plurality of individual measurements at the specific points of time 33 are determined to identify the reflected signal pulse. Furthermore, this aspect of Applicant's invention is clearly claimed in each of the independent claims.

The Patent Examiner, recognizing this deficiency of Lai, further relies upon the Ogawa patent. However, the Ogawa patent has been previously discussed and simply does not solve the deficiency of the Lai publication.

Applicant does not claim to have invented the first time measuring method or apparatus which utilizes the TOF principle. Rather, Applicant merely claims to have invented a method and apparatus which simply but effectively identifies the return or echo pulse of the signal even when the signal is below the noise level and Applicant achieves this with minimal computing power. The prior art simply does not teach Applicant's particular method or apparatus.

In view of the foregoing, Applicant respectfully submits that this case is in condition for formal allowance and such action is respectfully solicited.

The Director is hereby authorized to charge any deficiency in the fees filed, asserted to be filed or which should have been filed herewith (or with any paper hereafter filed in this application by this firm) to our Deposit Account No. 07-1180.

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Respectfully submitted,

By _____

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